Office of Naval Research International Liaison Office

Ocean Science and Engineering Newsletter 3

Report on the Site visits to S&T institutes in Chile: Ocean S&T, Materials S&T, and Naval Architecture/Shipbuilding (25-29 March 2002).

By (in alphabetic order)
Prof. Hassan B. Ali, Associate Director, Office of Naval Research ILO
Larrie Ferreiro, Associate Director, Office of Naval Research IFO
Dr. Sonia Gallegos, Naval Research Laboratory, Stennis Space Center
Lilia Ramirez, Group coordinator**,** Head, ONR International Liaison Office
Dr. Joe Tischler, Naval Research Laboratory
Prof. Colin Wood, Program Officer, Office of Naval Research

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These reports summarize global activities of S&T Associate Directors of the Office of Naval Research International Field Offices (ONRIFO). The complete listing of newsletters and reports are available under the authors' by-line on the ONRIFO homepage: http://www.ehis.navy.mil/ http://www.ehis.navy.mil/onrnews.htm or ONRIFO-Asia homepage: http://www.onr.navy.mil/onrasia/, or by email to respective authors.

Contents:

***Key Words**: oceanography; oceans; ocean optics; bio-optics; upwelling; satellite tracking; Tsunami; Humboldt Current System; phytoplankton; methane hydrates; Drake Passage; X-ray evaluation of materials; biologically assisted corrosion; Ferro-electrics; thin films; metrication; naval architecture; shipbuilding.*

Figure 1: View from the Office of Hydrography and Oceanography, Valparaiso

I. Summary

During the period 25-29 March, several representatives from the Office of Naval Research (ONR) and the Naval Research Laboratory (NRL) visited a number of Chilean universities, government facilities, and other establishments involved in science and technology. We were joined in these visits by Capt. Mani Malagon, U.S. Navy, the prospective Defense Attaché to Chile. The main goals of these visits were three-fold: to perform a preliminary assessment of current science and technology (S&T) in several areas of interest to ONR; to promulgate ONR's interest and efforts in enhancing international collaboration, particularly via its International Field Office (IFO); and to explore the possibilities of immediate collaboration with Chile.

Because of the many relevant sites to visit in a short period of time, the group was divided into smaller groups by area of expertise (Ocean S&T; Materials; and Naval Architecture/Shipbuilding0. Separate visit schedules were arranged for each group. This action enabled a broad coverage of sites in several Chilean cities.

The **Ocean S&T** group visited several departments of the University of Chile, the University of Concepcion, the Hydrographic Office, the Catholic University of Valparaiso, and the University of Valparaiso. The Oceanography Division of the **University of Chile** is conducting research in **marine bio-optics** and **phytoplanktonic** studies of the water column, with particular interest in the bio-optical parameters in the Fjords of Chile. **Environmental modeling, Chilean upwelling**, and the prediction of **land-based processes** are other areas of interest.

The **Center for Space Studies**, a self-financing institute of the University of Chile, is an international S&T service organization engaged in **tracking and monitoring of international satellite launches**. They have supported over 370 missions over a period of more than 42 years and have archived over 20 years of data from visible and IR bands from different sensors, such as AVHRR and Landsat. They are interested in reprocessing these data to create climatologies for the Southern Hemisphere, which currently do not exist. At the **Geographical Information Systems Division** of the Center for Space Research we were briefed on the analysis methodology of AVHRR data to track seasonal changes in the Chilean upwelling, highly relevant for fisheries and oceanographic studies**.**

The Oceanography Department of the **University of Concepcion** is investigating a number of areas of **ocean dynamics** and **physical oceanography**, with emphasis on the **Humboldt Current System.** They have just received a $1M grant from the Chilean Govt. (based on a competitive proposal evaluated by U.S. and French experts) to build an **Ocean Science Center.** A major problem these scientists currently face, along with most oceanographers in Chile, is the **lack of a research vessel.**

The products of the **Office of Hydrography and Oceanography** of the Chilean Navy are analogous to those produced by NOAA; they produce weather and sea conditions for the public in general. One of their current interests involves the prediction of **Tsunamis**

along the coast of Chile. They maintain 16 coastal stations, from which data is broadcast via GOES satellite. They carry out five to six oceanographic surveys of the coast of Chile per year, and have very good ocean modelers.

The **Catholic University of Valparaíso** has a particular interest in deep ("blue") water oceanography, especially the **deep basins** and the **Humboldt Current.** They are also engaged in a major international collaborative effort to locate **methane hydrate deposits** in the continental shelf of Chile. Their **remote sensing** efforts are supported by a **NOAA/SeaWiFS** antenna **to observe the ocean in the visible and infrared bands**.

The discussions at the **University of Valparaíso** focused on their **Marine Biology** program and **Ocean Engineering** Department. They are interested in upgrading their Ocean Engineering Department to the level of a B.Sc. granting intuition. Also, interest was expressed in U.S. personnel, both as teachers, and as advisors, for their oceanography program. Dr. Helmut Sievers shared with us his unfinished, meticulously prepared manuscript of the oceanography of the **Southern Ocean** and **Drake Passage.** He wishes to collaborate with an interested and knowledgeable scientist to complete the document and produce a scientific paper.

The **Materials** group visited the University of Chile, the Catholic Pontifical University, the University of Santiago, the **National Standards Institute**, and the Catholic University of the North. At the **U.S. Embassy** in Santiago, options for **Fulbright** interchanges between US and Chile/South America were discussed, and ONR involvement in proposal evaluation for Navy-relevant candidates was offered.

At the **University of Chile X-ray evaluation of materials** and the **crystal atomic structure** identification of **pharmaceuticals** was discussed with researchers in the Physics Department. Also, a possible connection with NRL for collaboration on X-ray science was investigated. The Chemical Engineering Department of the university is interested in collaborative possibilities on **biologically assisted corrosion** and **molten salt deposition of Ferro-electrics** and other active dielectric characterization and analysis of Si and SiC.

Opportunities for collaboration in the **surface analysis of materials** and **Ferro-electric thin films** were explored at the **Catholic Pontifical University.** They have deposition and surface analytical techniques, which would be a good topic area for future potential collaboration. Subsequently, there was also a meeting with Professor Francisco Claro, Co-chair for the ONR-supported meeting on "Multifunctional Materials and Applications," to be held in Pucon, Chile, in late October 2002. We discussed arrangements, invitation procedures, visiting scientists, meeting format, etc.

At the **University of Santiago** we discussed NICOP opportunities with the Metallurgy Department, but found no real match, as their activity was primarily at an undergraduate level in conventional metallurgical studies.

The Chilean **National Standards Institute** is involved with the U.S. National Institutes of Standards and Technology (NIST). We discussed the national initiatives in

standardization and **metrication**, but saw significant advantage of ONRIFO further involvement.

The possibilities of collaboration under NICOP and VSP programs were discussed with professors in the Chemistry and Mining Science departments of the **Catholic University of the North**, but we saw little overlap with Navy interests, except for the National Congress of Chemistry.

The **Naval Architecture** group visited a Lloyd's Register representative, ASMAR (Navy Shipyards and Arsenals), and the Federico Santa Marie Technical University. **Lloyd's Register** is one of the principal ship classification societies operating in Latin America. As such, they are an important point of contact for future investigations within Latin America. Chile's shipbuilding capability is limited but adaptable. The R&D for naval architecture and shipbuilding is also rather limited in Chile, both in universities as well as industry. There is only one school that teaches naval architecture: the Universidad Austral, located in Valdivia, which has a small towing tank for very limited research.

ASMAR (Astilleros y Maestranzas de la Armada) **Navy Shipyards and Arsenals** is a government-owned shipyard with three facilities along the coast. It is fully funded through its contracts with the Chilean Navy and its construction and repair work. The principle yard is within the Chilean naval base in Talcahuano (near Concepción), with two smaller facilities in Valparaiso and Punta Arenas The ASMAR yard in Talcahuano is principally a repair yard but can handle new construction of small vessels. Its position in the South Pacific makes it ideal for ship repairs, which is the principle source of income. It has two drydocks (one for up to 96,000 tons) and several floating docks (up to 4,500 tons), and a construction slipway for ships up to 50,000 tons. ASMAR also jointly owns: SISDEF in Valparaiso, with GEC (UK), which designs and builds naval electronic systems and software; and SOCIBER in Valparaiso, with Izar (Spain), which repairs and modernizes ships.

The **Universidad Tecnica Federico Santa Maria** (Federico Santa Maria Technical University), Valparaiso, provides education at the technician, undergraduate and graduate levels in engineering, science and administration. It has a fairly strong graduate research program in electrical engineering, mechanical engineering, civil engineering and physics. Most of the R&D at the university level is funded through CONICYT (Comisión Nacional de Investigación Científica y Tecnológica, or National Commission for Science and Technology Research), and most of the funding goes to basic research. University/industry interaction is still at a low level, but improving. A considerable amount of interaction with US academia was evident, even though little of it showed up in citation searches.

II. Site Visits

Overview

In a relatively short period of time a great deal of ground was covered, both literally and figuratively. This was accomplished by dividing the group into smaller groups by area of

expertise (ocean-related S&T; Materials; and Naval Architecture/shipbuilding) and arranging separate visit schedules for each group.

The main goals of these visits were three-fold: to perform a preliminary assessment of current S&T in several areas of interest to ONR; to promulgate ONR's interest and efforts in enhancing international collaboration, particularly via its International Field Office (IFO); and to explore the possibilities of immediate collaboration with Chile.

Usually the director of each center and the principal investigators joined the discussions, which were in Spanish and/or English, depending on the occasion. In most places visited, the Chilean participants were comfortable, if not fluent, in English, but in some cases Spanish was deemed necessary. At each meeting, an overview presentation was made on ONR, with particular emphasis on ONRIFO's mission, and examples of international collaborative projects. In addition, in the ocean S&T visits, Sonia Gallegos presented her work in the Yellow Sea, as an example of collaboration among scientists from different countries. This presentation emphasized to the Chilean scientists that our visit was concerned with collaboration in fundamental aspects of science and technology.

A. Ocean Science and Technology (Prof. Hassan B. Ali and Dr. Sonia Gallegos)

1. University of Chile, Santiago de Chile

The University of Chile, founded in 1842, is the largest university in the country, with over 22,000 students. It contributes approximately 50% of the scientific production of Chile.

- **Oceanography Division**

Dr. Vivian Montecino, a graduate of the University of Kiel in Germany, was our point of contact for this visit, but she arranged for us to meet members of other departments, including the geology department, the Marine Science Department, and the Geographical Information System Division of the Center for Space Research of the University of Chile. We visited the laboratories of Dr. Montecino and Dr. Victor Marin, a graduate of Scripps Institution of Oceanography. Here, we had the opportunity to talk with some of the students working at the laboratory and learned about their research in **marine bio-optics** and **phytoplanktonic** studies of the water column. One of Dr. Montecino's interests is the study **bio-optical parameters in the Fjords of Chile**. These are very complex environments, which are practically unknown to us because they occur in very few places on earth, one of which is Chile. Dr. Montecino has instruments to study the **apparent optical properties** of the water; her study will greatly benefit from the addition of instrumentation to also study the **inherent optical properties**. Both types of optical properties are needed for naval applications.

Dr. Marin is involved in **environmental modeling** and in the prediction not only of oceanographic phenomena, such as the **Chilean upwelling**, but also **land-based processes** such as fires. His methodologies are very much up to date and can be easily applied to basic research, as well as to applied Navy research.

Both Dr. Montecino and Dr. Marin are interested in participating in a NICOP proposal to ONR. Dr. Montecino is currently writing a proposal to the Chilean Government that she thinks will be of interest to ONR, as well as to the NICOP program.

- **Center for Space Studies**: Dr. Eduardo Diaz, the Center Director; Ms. Alicia Reyes, the head of Public Relations.

The Center for Space Studies, established in 1959, is an international S&T service organization engaged in **tracking and monitoring of international satellite launches**. The Center is part of the Faculty of Physical and Mathematical Sciences of the University of Chile. Their tracking station is located 40 km north of Santiago, and occupies a large area of land (100 Hectares) containing well-equipped, state-of-the-art facilities and excellent conditions for telecommunication. They also have a remote sensing laboratory located in downtown Santiago and an additional tracking station on Easter Island. The Center's role is to track, under contract, the satellites and to insure that they maintain correct orbital parameters. Deviations from the programmed ephemeris are reported to the agency launching the satellites, which then performs the correction necessary to bring the satellite back on track. Their ideal location in the Southern Hemisphere, and the expertise of the Center engineers, makes this the appropriate center for such post-launch satellite interactions. For the telemetry, tracking and command support (TTC) the Center uses 3 in-house built antennae: 12 meter, 9 meter, and 7 meter, with compatible equipment to cover the VHF, S, L, and X frequency bands. An example of one of these antennae is shown in Figure 1.

The Center is largely a self-financing institute, depending for its survival on its expertise and performance. They have worked with many international space agencies, including NASA, the Japanese NASDA, the European Space Agency (ESA), the French CNES, the Chinese CLTC, among others, as well as private corporations and research organizations. They have **supported more than 370 missions** over a period of more than 42 years, including the first U.S. satellite, Explorer 1. They have been involved with systems such as Venus Probe, Galileo, Ulysses, the Motorola Irridium satellites, the Japanese ADEOS, the ESA X-ray XMM, IKONOS, SPOT, GOES, Landsat, and many others. They have archived over **20 years of data from visible and IR bands** from different sensors, such as AVHRR and Landsat, and would like to reprocess these data in order to create climatologies for the Southern Hemisphere, which currently do not exist. These interesting data, useful for Navy SST efforts, may not even be available in NOAA archives.

Their National Program mission is to leverage spin-offs of space S&T for national purposes. One of their main interests, for example, is to use the data they collect to address such national issues as fires, tracing upwelling trends, and forecasting earthquakes. For the latter, they feel that ONR can help with their earthquake-forecasting efforts to by monitoring changes in the ionosphere.

Figure 2: One of the satellite antennae of the Center for Space Studies, University of Chile

- **Geographical Information Systems Division of the Center for Space Research**

The **Geographical Information Systems Division** of the Center for Space Research is composed mostly of geographers, software engineers and information engineers. Their role is to utilize the data collected by the systems they help to track. The data is stored and then analyzed using mathematical and commercial or proprietary GIS systems. The applications are geared towards supporting other projects at the University or to address an environmental need in Chile. We were briefed on the analysis methodology of AVHRR data to track seasonal changes in the Chilean upwelling, a highly relevant phenomenon for fisheries and oceanographic studies.

2. The University of Concepción Oceanography Department

Our POC was Dr. Osvaldo Ulloa. We met with the principal investigators as well as with the members of the administration. The University of Concepción, like other Chilean Universities, has highly qualified scientists, who hold doctoral degrees from prestigious universities in the U.S., Europe, Canada, and Japan. They have close ties with many colleagues abroad and have exchange programs for students and professors with a number of universities, including Harvard and Woods Hole, and they are interested in further collaboration with groups in the United States.

The University of Concepción Oceanographic group seems to be among the wealthiest groups we encountered. Also, most of the scientists we met were fairly young, energetic, and dynamic. It appears that they have been quite successful in their pursuit of funding sources**.** The Oceanography Department recently received a $1M grant from CONICYT to build an **Ocean Science Center,** based on a competitive proposal evaluated by foreign experts (U.S. and France). CONICYT, the Chilean Government's National Commission for Science and Technology Research, is the equivalent of NSF (the U.S. National Science Foundation).

The University of Concepción, along with a number of other Chilean universities, is taking part in the FONDAP-Humboldt Program. FONDAP is the Fund for Advanced Investigation in Areas of Priority (Fondo de Investigación Avanzada en Áreas Prioritarias). "The FONDAP-Humboldt Program (FHP) involves, for the first time in Chile, a substantial financing, on mi-term basis, of a multi-institutional, multi-disciplinary, university-based research effort in the field of oceanography. Under this scheme, the FHP has been addressing the study of some of the most salient features of one of the largest and most productive, yet least known marine ecosystems in the world, the **Humboldt Current System** off Chile (HCS). During this program the CONICYT selected Committee of PI's has applied an ecosystemic approach and has included a relatively large human resource base to successfully fulfill the objectives set out in the work program of the FHP. The experience accumulated so far indicates that the currently used FONDAP model is the most appropriate type of research program for understanding some of the main features of the HCS off Chile. The FHP has also resulted in a valuable integration of research efforts among national oceanographers that directly participate or collaborate with the program as well as playing a very important role in the training of young scientists. The FHP is also involved in an extremely important international collaborative effort, which is helping to consolidate the research and training initiatives of the program."

As noted, the scientists here have recently received substantial funding from their government. They are currently building labs and purchasing equipment for deployment, but the main problem these scientists face, like most of the oceanographers in Chile, is the **lack of a research vessel.** The current vessel, belonging to the Navy Hydrographic Institute, will be taken out of commission within three years; there is no replacement in sight.

3. The Office of Hydrography and Oceanography

Ms. Michelle Manley Barber (Marine Biologist) was our POC here. We visited the Oceanography Department of the Navy's Office of Hydrography and Oceanography and met with Dr. Mario Caceres, Head of the Technical Division (an Old Dominion University graduate). He explained the role the institute plays for the Navy and the community in general, and the products and needs of the institute. The products of this institute are **analogous to those of NOAA**; they produce weather and sea conditions for the public in general. They are very interested in **coastal models** and in implementing **wave models**, particularly for use the prediction of **Tsunamis** along the coast of Chile, and welcome any information or point of contact in the USA that would help them to augment their knowledge of this particular phenomenon. They carry out five to six oceanographic surveys of the coast of Chile, and are currently modeling the Valparaiso Bay using a coastal model. They have very good ocean modelers here. In fact, the head of the Department of Oceanography, CDR Rodrigo Nunez, is a graduate of Florida State University and comes from one of the top oceanographic modeling groups in the USA, the O'Brien group.

They maintain 16 coastal stations, from which data is broadcast via the Geostationary Operational Environmental Satellite (GOES). They are also in the process of acquiring an antenna to capture ocean-related data such as SST.

4. The Catholic University of Valparaíso

The POC for this visit was Dr. Sergio Salinas of the School of Marine Science, of the Faculty of Natural Resources. We met with him and several of his colleagues at the University. Various investigators briefly discussed their research efforts. Included amount the latter were: **Coastal ocean circulation** off Western South America, (touching on atmosphere-ocean interaction, **coastal upwelling**, fisheries activities, etc.); the scientific cruises among the numerous and fascinating **Chilean fjords**, inlets, rivers, channels and gulfs in the region of the southern coastline of Chile (including the physical and chemical investigations of the **surficial sediments**); and **methane hydrates**. The research emphasis appears to be on "blue water" oceanography, mainly the **deep basins** and the **Humboldt Current.** For remote sensing, they have a NOAA/SeaWiFS antenna. Data from this antenna provides views of the ocean in the visible and infrared bands.

The university is involved in a major international collaborative effort centered on the analysis of seismic data to locate marine **methane hydrate** deposits. The keen interest in examining the very extensive deposits of marine methane hydrates along the Chilean continental margin is driven by a major need in Chile to find its own methane deposits (currently Chile imports this gas from Argentina). The international collaborative effort, supported by the Fund for Fostering Scientific and Technological Development (FONDEF in Spanish), involves the Catholic University of Valparaiso, the University of Chile, the Chilean Navy Hydrographic Institute, energy companies, ministries, etc., from Chile, the USA, Germany, Denmark, Canada, and Norway. The Director of the project is

Dr. Esteban Morales Gamboa (emorales@ucv.cl), while the principal Chilean investigator is Dr. Juan Diaz Naveas (jdiaz@ucv.cl). Methane Hydrates are important for a number of reasons: there is evidence that methane hydrates are associated with **seafloor instability**; they can produce **acoustic scattering** and acoustic propagation anomalies that could adversely **impact Navy acoustic systems**; they also represent a potential new **source of energy**, especially for countries that lack conventional hydrocarbon reserves. We mentioned to them that NRL is conducting a broadly based research program to study methane hydrates. NRL scientists have studied methane hydrates off the East Coast of the United States (Blake Ridge), on the Cascadia Margin (off Vancouver Island), in the Gulf of Mexico, in the Nankai Trough off Japan, and elsewhere.

Some of the results of the university's investigations in marine science and technology are published in their attractive bi-annual journal "Marine Investigations," edited by the School of Marine Science, of the Faculty of Natural Resources. The particular issue we saw heavily emphasized investigations of fish or related biological activity in the Southeastern Pacific. Publication of their research in major international journals is largely precluded by the exorbitant cost of publication.

5. The University of Valparaíso

We met with Dr. Hellmuth Sievers and the coordinator of the Ocean Engineering department. Dr. Sievers provided an insight into the **Marine Biology program** and their efforts to get the Ocean Engineering program to the level of producing a B.S. Program. At present, the Ocean Engineering Program is geared towards meeting local needs rather than a generalized program. They requested information on Oceanography programs in the U.S. and personnel interested in teaching courses at their University. Dr. Helmut Sievers shared with us his unfinished, meticulously prepared manuscript of the "oceanography" of the Southern Ocean, including the **Drake Passage** [The Drake Passage is a 600 mi (1,000 km) wide strait, located about 100 mi (166 km) north of the Antarctic Peninsula, connecting the Atlantic and Pacific oceans between Tierra del Fuego (the southern tip of South America) and the S. Shetland Islands. The **Southern Ocean** is a major component of the coupled ocean-atmosphere climate system. It connects all the other major oceans and influences the water mass characteristics of the deep water over a large portion of the world. It is an area of net heat loss from the ocean to the atmosphere, and is the conduit for substantial heat and freshwater exchange between the ocean basins].

Prof. Sievers' manuscript contains a large number of figures based on data from 949 oceanographic stations, in an area between 39°W and 95°W longitude and 50°S latitude to Antarctica. The figures, which span the entire area, include horizontal and vertical distribution of water characteristics (temperature, salinity, density, dissolved oxygen, nutrients), hydrostatic stability, identification of water masses, the topography of the density surfaces associated with the cores of these water masses, boundaries among the water masses, zonation, and relative geostrophic flow. The vertical distributions comprise three north-south sections and three east-west sections. The E-W sections run between the Fronts along the Sub-Antarctic, Polar Frontal and Antarctic zones. He has also prepared a fourth N-S section farther east (Scotia Sea) which constitutes a second manuscript. Prof. Sievers prepared this manuscript, manually, a number of years ago, in collaboration with an American scientist at Texas A & M University who subsequently could not work on the manuscript. Because English is not his native language (Spanish

and German are), Prof. Sievers wishes to collaborate with an interested and knowledgeable scientist to complete the document and produce a scientific paper.

They also expressed interest in inviting a noble laureate (Prof. Joseph Stiglitz, Colombia University) to participate in an International Congress being planned for October 1 at the University of Valparaiso (the International Congress on the Environment and Sustainable Development 2002).

B. Materials (Drs. Joe Tischler and Prof. Colin Wood)

1. U.S. Embassy, Santiago

We met with the Public Relations person, David Bustamente, and discussed at length options for **Fulbright** interchanges between US and Chile, and with South America in general. We also offered ONR involvement in proposal evaluation for Navy-relevant candidates.

2. University of Chile

We met with Dr. Anna Maria Covarubias and Mr.Rafael Nunez of the Physics Department and discussed the **X-ray evaluation of materials** and the **crystal atomic structure** identification of **pharmaceuticals**. We investigated a possible connection with NRL for collaboration on X-ray science.

We discussed with Professor Tomas Vargas of the Chemical Engineering Department collaborative possibilities on **biologically assisted corrosion** and **molten salt deposition of Ferro-electrics** and other active dielectric characterization and analysis of Si and SiC

3. The Catholic Pontifical University

We met with Professor Miguel Kiwi, Ulrich Volkmann, and colleagues of the Physics Department and discussed collaborative opportunities in **surface analysis of materials** and **Ferro-electric thin films**. They have deposition and surface analytical techniques, which would make for a good topic area for future potential collaboration.

4. The University of Santiago

We met with Professor Bernd Schultz Eglin of the Metallurgy Department and discussed NICOP opportunities, but found no real match, as their activity was primarily at an undergraduate level in conventional metallurgical studies.

We met with Professor Francisco Claro, Co-chair for the ONR-supported meeting on "Multifunctional Materials and Applications," to be held in Pucon, Chile, in late October 2002. We discussed arrangements, invitation procedures, visiting scientists, meeting format, etc.

5. The National Standards Institute (Instituto Nacional de Normalización, INN)

We met with head of the National Standards Institute and discussed the national initiatives in standardization and **metrication**. INN is already heavily involved with the U.S. national Institutes of Standards and Technology (NIST). Therefore we judged there was no significant advantage of ONR IFO further involvement.

6. The Catholic University of the North

Professor Carlos Mujico, Department Head, and other professors in Chemistry and Mining Science, discussed with us the possibilities under NICOP and VSP programs, but we saw little overlap with Navy interests, except for the National Congress of Chemistry. They would appreciate assistance in inviting US visitors.

C. Naval Architecture

1. Interview with Raúl Cancino, Senior Surveyor, Lloyd's Register, Talcahuano

Mr Cancino is a former Chilean naval officer who now works for Lloyds Register, overseeing vessels at ASMAR. Lloyd's Register (www.lr.org) is one of the principal ship classification societies operating in Latin America. Another major classification society is the American Bureau of Shipping. The role of classification societies in survey and inspection of vessels during design and construction, as well as through-life, make them uniquely qualified to observe the state of technology as applied to shipbuilding as well as to the ships and ocean platforms themselves. They increasingly have a hand in the development of technical standards for naval vessels. As such, they are an important point of contact for future investigations within Latin America.

Some highlights:

- Chile's shipbuilding capability is limited but adaptable. The ASMAR yard in Talcahuano is principally a repair yard but can handle new construction of small vessels. The ASENAV yard at Valdivia is a private yard that specializes in ferries, tugs and yachts, and has built fast patrol craft.
- The R&D for naval architecture and shipbuilding is also rather limited in Chile, both in universities as well as industry. There is only one school that teaches naval architecture: the Universidad Austral, located in Valdivia, which has a small towing tank for very limited research.
- ONR could act as a catalyst for stimulating cooperation in science and technology at the government and industrial levels

2. ASMAR (Astilleros y Maestranzas de la Armada) Navy Shipyards and Arsenals

People visited: CAPT Heinz Pearce Poffan, Administrator
CAPT Hugo Barra Salcedo, Repairs Manager
Ing Luis Ernesto Siebert Cristi, Head of Engineering
Mr Sergio Diaz, Naval Architect

ASMAR (www.asmar.cl) is a government-owned shipyard with three facilities along the coast. The principal yard is within the Chilean naval base in Talcahuano (near Concepción), with two smaller facilities in Valparaiso and Punta Arenas. Its position in the South Pacific makes it ideal for ship repairs, which is the principle source of income. It has two drydocks (one for up to 96,000 tons) and several floating docks (up to 4,500 tons), and a construction slipway for ships up to 50,000 tons. ASMAR also jointly owns: SISDEF in Valparaiso, with GEC (UK): design and build of naval electronic systems and software; and SOCIBER in Valparaiso, with Izar (Spain): repair and modernization of ships

Some highlights:

- ASMAR is fully funded through its contracts with the Chilean Navy and its construction and repair work.
- ASMAR carries out repair and modernization of all hull, mechanical and electrical systems, as well as many combat systems (guns, radars) for all ships and submarines of the Chilean navy, and has completed an extensive modernization of an Argentine frigate.
- ASMAR has built several naval vessels (logistics support, fast patrol and tank landing ships) of up to 3,000 tons. Its principal new-construction business is in fishing vessels, although it recently built a 2,700 ton fisheries research vessel for Iceland. Design work is carried out using the FORAN CAD system, a very capable system developed by SENER of Madrid, which has a Spanish-language interface. It would require some considerable investment and foreign technology transfer to construct frigate-size ships, including about $17 million to increase pre-outfitting and improve production flow. This would include the installation of two 200 ton cranes, covering the launch slip and other desired areas, and installing an accuracy system to ensure going from the current 10% preassembly to 90% preassembly.
- ASMAR is sensitive to sound quieting. In addition to performing submarine repairs, the fisheries research vessel for Iceland was built to be among the quietest in the world.
- ASMAR has shown itself quite capable of adapting foreign technologies for its particular needs, e.g. fitting of acoustic dampening systems and improvements to the mechanical systems for the Iceland research vessel.
- The engineering staff was quite professional and well-informed about current naval developments. Many were trained in the USA and Europe, and senior staff usually had Master's degrees or higher. During the 1970s, the Chilean Ministry of Defense had little contact with other countries except South Africa, South Korea, Israel, and Taiwan, requiring a great deal of autonomy in development. Since then, they have established good connections with other navies, notably the US and UK Navies.

3. The Federico Santa Maria Technical University, Valparaiso

People visited: Dr. Hector Jensen, Associate Professor of Civil Engineering
Dr Carlos Aguirre Ahumada, Director of Civil Engineering
Dr Fernando Labbé Zepeda, Professor of Mechanical Engineering

Universidad Tecnica Federico Santa Maria (www.utfsm.cl) provides education at the technician, undergraduate and graduate levels in engineering, science and administration. It has a fairly strong graduate research program in electrical engineering, mechanical engineering, civil engineering and physics.

The purpose of the visit was primarily an introduction to the academic environment in areas related to naval architecture and shipbuilding, and establishing contacts both at that university and elsewhere for discussing the potential of future cooperative efforts. Some highlights:

- Most of R&D at the university level is funded through CONICYT, which is the equivalent of the US National Science Foundation. Most of the funding goes to basic research.
- University / industry interaction is still at a low level, but improving
- A considerable amount of interaction with US academia was evident, even though little of it showed up in citation searches. For example, Prof. Jensen has produced a number of papers on system optimization in conjunction with UCLA
- ONR could be helpful in opening up R&D capabilities within Latin America to US and other researchers

III. Assessment

Although the site visits to Chile took place over a relatively short period of time, the trip was sufficient to demonstrate that Chile's capabilities and infrastructure in broad areas of science and technology are very impressive.

In the **ocean sciences** area we found highly competent researchers, working in areas of relevance and importance to the Navy. In some cases (e.g., oceanography/bio-optics of fjords; archived visible and infrared data; methane hydrates) they may have expertise and/or data that we lack. We found interest, even enthusiasm, for collaborating with ONR/NRL. Chile's international collaborations have been principally with Europe, a fact largely attributable, in their perception, to the lack of U.S. interest in Latin America. A major deficiency in the Chilean ocean S&T area is the lack of a research vessel.

Chile has a very strong investment in the **theoretical** area **of materials**, but is very limited in experimental and practical science and technology, due mainly to economical issues (lack of funds to purchase equipment, problems with local customs, etc.). Collaboration between Chilean theorists and both experimental and theoretical groups in

the U.S. could prove to be mutually beneficial. There are good possibilities for joint research in Melt growth technique for dielectrics and ceramics, bio enhanced corrosion, and the surface characterization and deposition of complex oxides.

There is a considerable amount of engineering and science knowledge resident within Chile, but the amount of R&D directly related to **naval architecture and shipbuilding** is very limited. Disciplines related to naval architecture, e.g., mechanical, electrical and civil engineering, appear to be rather better represented and should be investigated more thoroughly. Future visits to Universidad Austral and to ASENAV, both in Valdivia, should be made to establish the levels of education and research.

In general, it is fair to say that Chile's science and engineering capabilities are far more impressive than can be ascertained from conventional "data mining." Publication of their research in major international journals is largely precluded by the exorbitant cost of the U.S.-based publications. As a result, Chileans tend to publish their research in local journals and conferences. Hence, future citation searches should be done in English, Spanish and Portuguese.

IV. Contacts

A. Ocean Science and Technology

1. University of Chile

- **Dr. Vivian Montecino Banderet**

Associate Professor
Casilla 653, Las Palmeras 3425, Santiago
Tel: 56-2- 2712977
Fax: 56-2-2727363
E-mail: clorofil@abello.dic.uchile.cl

- **Dr. Victor Marin**

Associate Professor
Casilla 653, Las Palmeras 3425, Santiago
Tel: 56-2-
Fax: 56-2-
E-mail: vmarin@antar.uchile.cl

- **Dr. Eduardo Diaz Araya**, Director,

Center for Space Studies,
A. Prat 1171-Casiila 411-3
Tel: 56-2-5553400-721816

- **Ms. Alicia Reyes**, Head, Public Relations

Center for Space Studies,
A. Prat 1171-Casiila 411-3
Tel: 56-2-6721816

E-mail: areyes@cec.uchile.cl

- **Dr. Gabriel Soto P.,**

Chief of National Programs
E-mail: gsoto@cec.uchile.cl

- **Dr. Pedro Paolini C.**

- **Jean-Yves Gaultier C.**

Telecommunications Specialist,
E-mail: jyves@cec.uchile.cl

2. University of Concepcion

- **Dr. Ciro Oyarzun Gonzalez**, Director,

Department of Oceanography,
E-mail: covarzun@udec.cl

- **Dr. Victor A. Gallardo**, Director,

Centro de Investigacion Oceanografioca (COPAS)
E-mail: vagallor@udec.cl

- **Dr. Osvaldo Ulloa, Director**

Programa Regional de Oceanografia Fisica y Clima
Cabina 7- Barrio Universitario
Casilla 160-C, Concepcion 3
E-mail: oulloa@profc.udec.cl

- **Dr. Franklin Carrasco Vasquez**, Dean,

Cabina 7- Barrio Universitario
Casilla 160-C, Concepcion 3
E-mail: fcarrasc@udec.cl

- Dr. Leonardo R. Castro,

E-mail: lecastro@udec.cl

- **Dr. Alberto Larrain Prat**

E-mail: alarrain@udec.cl

3. Office of Hydrography and Oceanography

- Dr. **Mario Caceres Munoz**, Head,

Technical Division,
Errazuriz 254-Playa Ancha,
Casilla 324, Valparaiso

Tel: 56-32-266672
E-mail: bio.fan.ac@shoa.cl

- **Cmdr. Rodrigo H. Nunez, Head**,

Department of Oceanography,
Office of Hydrography and Oceanography,
Errazuriz 254-Playa Ancha,
Casilla 324, Valparaiso
Tel: 56-32-266670
E-mail: munez@shoa.cl

- **Ms. Michelle Manley Barber**,

Department of Oceanography,
Office of Hydrography and Oceanography,
Errazuriz 254-Playa Ancha,
Casilla 324, Valparaiso
Tel: 56-32-266542
E-mail: bio.fan.oc@shoa.cl

4. Catholic University of Valparaiso

- **Mr. Sergio Salinas**,

School of Marine Science,
Faculty of Natural Resources,
Avda Altamirano 1480-Castilla 1020,
Valparaiso,
Tel: 56-32-274245
E-mail: ssalinas@ucv.cl

- **Dr. Esteban Morales Gamboa**

Avda Altamirano 1480-Castilla 1020,
Valparaiso,
Tel: 56-32-274254
E-mail: emorales@ucv.cl)

- **Dr. Juan Diaz Naveas**

Avda Altamirano 1480-Castilla 1020,
Valparaiso,
Tel: 56-32-274269
E-mail: jdiaz@ucv.cl).

- **Nelson Silva S.**

E-mail: nsilva@ucv.cl

- **Dr. Sergio Palma G.**

E-mail: spalma@ucv.cl

5. University of Valparaiso

- **Dr. Hellmuth Sievers**

Faculty of Marine Sciences
Casilla 13-D, Viña del Mar
Tel: (56-32) 507844
Fax: (56-32) 507859
E-mail: hellmuth.sievers@uv.clail

B. Materials

1. University of Chile

Dr. Anna Maria Covarubias and Mr. Rafael Nunez of the Physics Department

Professor Tomas Vargas of the Chemical Engineering Department

2. Catholic Pontifical University

Professor Miguel Kiwi, Ulrich Volkmann, and colleagues of the Physics Department

3. The University of Santiago

Professor Bernd Schultz Eglin of the Metallurgy Department

Professor Francisco Claro

4. The National Standards Institute

5. The Catholic University of the North
Professor Carlos Mujico, Department Head

C. Naval Architecture

1. Lloyd's Register of Shipping

Raul Cancino

Lloyd's Register, Talcahuano

E-mail: talcahuano@lr.org

2. ASMAR

CAPT Heinz Pearce Poffan, Administrator,

E-mail: hpearce@asmar.c

CAPT Hugo Barra Salcedo, Repairs Manager
E-mail: hbarras@asmar.cl

Ing Luis Ernesto Siebert Cristi, Head of Engineering,
E-mail: isiebertc@asmar.cl

Mr Sergio Diaz, Naval Architect
E-mail: sdiaz@asmar.cl

3. The Federico Santa Maria Technical University, Valparaiso

Dr. Hector Jensen, Associate Professor of Civil Engineering
E-mail: hjensen@ociv.utfsm.cl

Dr Carlos Aguirre Ahumada, Director of Civil Engineering
E-mail: caguirre@ociv.utfsm.cl

Dr Fernando Labbe Zepeda, Professor of Mechanical Engineering
E-mail: fernando.labbe@mec.utfsm.cl

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